METHOD AND APPARATUS FOR HIGHLIGHTING GRAPHICAL OBJECTS

Cross Reference to Related Application

[0001] The application claims the benefit of the filing date of U.S. application No. 60/416,494 filed on 4 October 2002 and entitled METHOD FOR DISPLAYING SELECTED OR HIGHLIGHTED OBJECTS USING RASTER COMPOSITING, which is hereby incorporated herein by reference.

Technical Field

[0002] The invention relates to the field of displaying graphic data and, in particular, to highlighting selected graphic objects on a display.

Background

[0003] Computer applications which permit users to work with graphic objects ("graphics applications") are widely used in various fields. One field where such applications are common is the graphic arts industry.

[0004] Graphics applications typically include a graphical user interface capable of displaying a number of graphical objects. The interface allows a user to select one or more of the objects to be the subject of the user's focus. The application may provide operations which may be applied to selected objects. For example, the application may permit selected objects to be moved, copied or deleted or permit properties of selected objects to be altered. The operations may be specified by any suitable user input including menu inputs, inputs from a

pointing device such as a mouse, keyboard inputs, voice inputs, or the like.

[0005] Selected objects are typically highlighted on the display so that the user can distinguish the selected objects from other, non-selected objects. Highlighting a selected object involves changing the appearance of the selected object in a manner which indicates to the user that the object has been selected. An example of an application in which it is desirable to highlight selected objects which are among closely adjacent non-selected objects is an application for configuring trapping objects for use in printing. Trapping objects are typically relatively small shapes, which are arranged along boundaries between different colored objects in multi-colored graphic data to be printed. Trapping objects may be placed along color boundaries to minimize the visual effect of any imperfections in the registration of the different colors which are used to print the graphic data. Sophisticated software applications for preparing graphic data for printing allow users to manipulate trapping objects and other objects contained within graphic data.

[0006] A graphical user interface may display graphic data comprising a number of different graphic objects. In most graphic applications, individual graphic objects are represented internally in a raster format, a vector format, or some combination of raster and vector formats. A raster format specifies color and other properties of an object on a pixel-by-pixel basis. A vector format defines an object using mathematical constructs.

[0007] Since most display and printing devices are raster-based, graphic applications typically include a rasterizer. A rasterizer is typically a system of hardware and/or software that receives the internal representations of the graphic objects to be displayed and produces raster or bit-map data suitable for display and/or printing. The raster data includes raster representations of each of the graphic objects. The process of producing raster data from a number of graphic objects (i.e. the process performed by a rasterizer) is sometimes called "rendering".

[0008] Raster and vector formats each have advantages and disadvantages. Objects in a vector format are easily identifiable and can be readily highlighted. A vector object does not have an inherent resolution and can be displayed in the highest resolution available. However, vector formats require computation time to be rendered into raster data suitable for display and/or printing.

[0009] Raster formats are readily and quickly displayed on computer displays (this is especially true when the resolution of the raster data matches that of the computer display on which the raster data will be displayed). However, highlighting a specific object represented in raster format for display presents a significant and complex challenge. For example, highlighting a circle within rasterized data requires identifying the pixels within the raster data which correspond to the circle and changing the visual appearance of some or all of those pixels to highlight the circle.

[0010] In cases where it is sufficient to highlight an object by identifying the general location of the object, a basic visual cue that an object is highlighted may be provided by displaying a rectangular shape (i.e. a bounding box) that surrounds the object. This simplistic approach may be inadequate when there is a need to distinguish between objects which are small, closely spaced and/or overlapping. At high zoom levels, the bounding box may fall partially or entirely outside of the field of view presented on the display. If the bounding box is outside of the field of view of the display, then a user may be incapable of determining (from the display) whether a particular object is highlighted.

[0011] In other cases it may be necessary to redraw the raster data on the display, so that highlighted objects are displayed with different visual cues that visually identify the objects as being highlighted. This task can be computationally intensive. To avoid display flicker while redrawing the display, current graphics applications use double buffering techniques.

[0012] Double buffering is performed with two memory buffers, both of which are associated with the same display. The contents of one of the buffers can be displayed while the contents of the second buffer are being manipulated. While one buffer is displayed, a computer application can manipulate the data in the second, hidden buffer to appropriately indicate highlighted objects. Once the second buffer has been populated, the graphics application causes the contents of the second buffer to be displayed, so as to show the highlighted objects. Switching between display buffers can reduce flickering. In some cases,

double buffering can require more display memory than might be desired.

[0013] From the foregoing, it can be seen that current techniques for highlighting objects have various deficiencies. These deficiencies are most severe in cases where graphic data to be displayed includes a large number of graphical objects. There is a need for improved methods and apparatus for highlighting objects on a display.

Summary of the Invention

[0014] This invention provides methods, systems and apparatus for highlighting selected objects on computer displays. One aspect of the invention provides a method for highlighting a selected object on a display. The method comprises rasterizing base graphic data comprising at least one graphic object including a selected graphic object to be highlighted to provide a base graphic raster; providing selection graphic data including a graphic object corresponding to the object to be highlighted; rasterizing the selection graphic data to yield a selection graphic raster; and, compositing the base graphic raster and the selection graphic raster to yield an output graphic raster for display.

[0015] In some embodiments of the invention the selection graphic data is provided by copying selected graphic objects from the base graphic data. The copied objects may be simplified before the selection graphic data is rasterized. Simplification of the copied objects may

involve replacing the copied objects with simpler objects having the same boundaries as the copied objects.

[0016] In specific embodiments of the invention, compositing the selection graphic raster and the base graphic raster involves one or more of setting areas of the output graphic raster corresponding to exposed areas of selected objects to certain highlighting colors, patterning the areas of the output graphic raster, or applying a function to invert or otherwise alter colors of the areas of the output graphic raster.

[0017] Another aspect of the invention provides a system for highlighting a selected object on a display. The system comprises a data processing system executing instructions which cause the data processing system to: rasterize base graphic data to provide a base graphic raster, the base graphic raster comprising at least one graphic object including a selected graphic object to be highlighted; provide selection graphic data including a graphic object corresponding to the object to be highlighted; rasterize the selection graphic data to yield a selection graphic raster; and, composite the base graphic raster and the selection graphic raster to yield an output graphic raster for display.

[0018] A further aspect of the invention provides apparatus for displaying a raster image with areas corresponding to selected objects highlighted, the apparatus comprises: a user interface configured to permit selection of one or more objects of base graphic data comprising a plurality of graphic objects; means for producing a selection graphic data wherein selected objects are represented by a highlighting attribute; a

rendering engine configured to rasterize the base graphic data to yield a base graphic raster and configured to rasterize the selection graphic data to yield a selection graphic raster; and, a compositing engine configured to composite the base graphic raster and the selection graphic raster to yield a graphic raster for display.

[0019] The invention may also be embodied in a computer-readable medium carrying instructions which, when executed by a data processing system cause the data processing system to execute a method according to the invention.

[0020] Further aspects of the invention and features of specific embodiments of the invention are described below.

Brief Description of the Drawings

[0021] In drawings which illustrate non-limiting embodiments of the invention:

Figure 1 is a block diagram illustrating a flow of information in a basic embodiment of the invention;

Figure 2 is a block diagram schematically illustrating an example of compositing a base graphic raster and a selection graphic raster;

Figure 3 is a flow chart which depicts an example routine for highlighting selected graphic object(s) on a display in accordance with a particular embodiment of the invention;

Figure 4 is a schematic depiction of a more detailed implementation of apparatus for highlighting selected graphic object(s) on a display according to a particular embodiment of the invention;

Figure 5 is a block diagram schematically illustrating an example of compositing a base graphic raster and a selection graphic raster wherein different highlighting techniques are used for different types of graphic objects; and

Figure 6 is a block diagram schematically illustrating a number of examples of generating selection graphic data where it is desired to highlight the exposed portion of a selected object.

Description

[0022] Throughout the following description, specific details are set forth in order to provide a more thorough understanding of the invention. However, the invention may be practiced without these particulars. In other instances, well known elements have not been shown or described in detail to avoid unnecessarily obscuring the invention. Accordingly, the specification and drawings are to be regarded in an illustrative, rather than a restrictive, sense.

[0023] This invention provides methods for highlighting one or more selected objects on a display. A rasterizer renders base graphic data containing one or more graphic objects to produce a base graphic raster. When a user selects object(s), selection graphic data is generated. The selection graphic data includes at least one or more selected graphic objects corresponding to the object(s) to be highlighted on the display. The rasterizer renders the selection graphic data to yield a selection graphic raster. The selection graphic raster and the base graphic raster are composited to yield a graphic raster for display wherein the selected object(s) are highlighted.

[0024] "Graphic object" is a broad term used by software engineers to describe elements of a file or stream which can yield an image capable of being displayed. A graphic object may consist of graphic data alone, functions, routines or procedures for generating or manipulating data or a combination of data and functions. Graphic objects may reside in data buffers, signals, or may be recorded in computer-readable media of any type. In some embodiments, of the invention, graphic objects are portions of a set of commands which define a set of one or more images in a description language such as a graphic description language or page description language.

[0020] The area of a raster image corresponding to a graphic object may be of any size. For example, a graphic object may yield an image which is as small as a single pixel or up to an arbitrarily large number of pixels. A graphic object may be represented in any suitable format. For example, raster objects may be represented in raster formats, vector formats, or any combinations of raster, vector and bitmap formats. A graphic object may comprise a plurality of other graphic objects. For example, a graphic object may comprise one or more stroke objects, fill objects or boundary objects. Some types of fundamental graphic objects may be referred to as "primitives". A graphic object may comprise a number of primitives.

[0021] In some embodiments of the invention, graphic objects are delineated by tags within a file or a stream of data. The tags may mark the beginnings and ends of graphic objects or otherwise delineate a

graphic object from among other graphic objects in a file or stream of data.

[0025] Figure 1 is a block diagram which illustrates a flow of data in a basic embodiment of the invention. The data flow illustrated in Figure 1 commences with base graphic data **102**. Base graphic data **102** includes one or more graphic objects. For example, base graphic data **102** may be a file containing graphic objects, a stream of data containing graphic objects and/or a data buffer containing graphic objects. Base graphic data **102** may be provided in the form of a set of statements in a graphic description language, a document markup language or a portable document format (e.g. ADOBE™ PDF format), for example.

[0026] Base graphic data **102** is sent to a rendering engine (i.e. a rasterizer) in block **106**, where it is converted into base graphic raster **110**. If none of the object(s) in base graphic data **102** is to be highlighted (as determined at block **113**), then base graphic raster **110** is displayed on a display **118**. If one or more objects in base graphic data **102** are to be highlighted, then selection graphic data **104** corresponding to the selected objects is generated and sent to a rendering engine in block **108**, where it is converted to selection graphic raster **112**. The same rendering engine may be used in both of blocks **106** and **108**.

[0027] Selection graphic data **104** identifies one or more selected graphic objects to be highlighted by means of one or more visual selection cues. The visual selection cue(s) used for highlighting may include, for example, one or more colors, patterns, color changes (such as

color substitutions or inversions), intensities, temporal flashing patterns, animations, or other visual characteristics which may be applied to all or parts of selected objects. Selection graphic data **104** may generally comprise any form of data capable of representing one or more graphic objects. In some embodiments, selection graphic data **104** is in the same format as base graphic data **102**.

[0028] When selected object(s) are to be highlighted (i.e. displayed with visual selection cues) base graphic raster **110** and selection graphic raster **112** are composited by a compositing engine **114** to yield graphic raster **116** for display on display **118**.

[0029] Compositing engine **114** receives base graphic raster **110** as a first input and selection graphic raster **112** as a second input and produces output graphic raster **116**. Output graphic raster **116** constitutes a modified version of base graphic raster **110**. When output graphic raster **116** is displayed, the object(s) selected by the user are highlighted. A graphic application can turn highlighting on by causing output graphic raster **116** to be displayed and can turn highlighting off by causing base graphic raster **110** to be displayed.

[0030] Compositing engine **114** uses selection graphic raster **112** to identify pixels in base graphic raster **110** which correspond to selected object(s). Compositing engine **114** alters the pixel values of output graphic raster **116** which correspond to selected object(s). The specific nature of the alteration performed by compositing engine **114** may be predetermined, or may be specified by information contained in selection

graphic raster **112** or may be determined in accordance with a particular logical highlighting routine based on selection graphic raster **112** and/or base graphic raster **110**.

[0031] Pixels of base graphic raster **110** have associated values which may be assigned by the rendering engine in block **106**. Selection graphic data **104** may be generated in a manner, such that after rendering in block **108**, pixels of selection graphic raster **112** which correspond to selected object(s) are assigned certain pixel values, or at least pixel values falling within certain ranges. The pixel values of output graphic raster **116** are determined by compositing engine **114**. Preferably, compositing engine **114** generates output graphic raster **116** having pixels with the same values as the pixels of base graphic raster **110**, except for pixels corresponding to selected object(s). The pixel values of output graphic raster **116** may be a function of one or both of the corresponding pixel values of selection graphic raster **112** and the corresponding pixel values of base graphic raster **110**. For example, for pixels corresponding to selected object(s):

- compositing engine **114** may generate output graphic raster **116** with pixel values which are the same as the pixel values of selection graphic raster **112**;
- pixel values of output graphic raster **116** may be determined by a highlighting routine, wherein the pixel values of selection graphic raster **112** determine functions to apply to corresponding pixel values of base graphic raster **110** to produce corresponding pixel values for output graphic raster **116**;

- the pixel values of output graphic raster **116** may be set to specific values which are mapped to by values of corresponding pixels in selection graphic raster **112**; and/or
- the pixel values of output graphic raster **116** may be determined by a highlighting routine based on both the pixel values of base graphic raster **110** and the pixel values of selection graphic raster **112**.

[0032] In some embodiments of the invention, highlighting can be turned on or off on display **118** by selecting between, base graphic raster **110** and output graphic raster **116**. In such embodiments, base graphic raster **110** is displayed at times when no highlighting is desired and output graphic raster **116** is displayed at times when highlighting is desired. These embodiments may comprise double-buffering techniques. In these double-buffering embodiments of the invention, highlighting can be turned on or off almost instantaneously.

[0033] In other embodiments of the invention compositing is performed in such a manner that the highlighting can be turned off by re-compositing output graphic raster **116** with selection graphic raster **112**. For example, if the compositing engine is configured to invert color values of selected objects, then re-compositing output graphic raster **116** with selection graphic raster **112** will invert the color values of the selected objects a second time and thereby restore the color values of the selected objects to their original values (i.e. the values of base graphic raster **110**). Compositing/re-compositing may be relatively fast in comparison to rasterizing graphic data. Re-compositing output graphic

raster **116** with selection graphic raster **112** can be performed repeatedly to flash the highlighting of selected objects on and off. The highlighting can be flashed on and off at a constant rate. The maximum rate may be dependent upon processing resources, such as the sizes of buffers holding selection graphic raster **112** and output graphic raster **116**.

[0034] Figure 2 is a block diagram which schematically illustrates a base graphic raster **202**, a selection graphic raster **204**, and an output graphic raster **208**. Output graphic raster **208** represents the compositing of base graphic raster **202** and selection graphic raster **204**. Base graphic raster **202**, selection graphic raster **204** and output graphic raster **208** may be stored in memory buffers for example. In Figure 2, base graphic raster **202** and selection graphic raster **204** have already been rendered by a suitable rendering engine.

[0035] Base graphic raster **202** comprises a number of graphic objects **209**. In the illustrated embodiment, graphic objects **209** are represented by text **209A**, parallelogram **209B**, circle **209C**, rectangle **209D**, triangle **209E**, star **209F** and ellipse **209G**. Selection graphic raster **204** comprises a number of selected graphic objects **210**. In the illustrated embodiment, a user has selected text **209A**, parallelogram **209B**, circle **209C** and rectangle **209D** for highlighting. Accordingly, the selected graphic objects **210** in selection graphic raster **204** include text **210A**, parallelogram **210B**, circle **210C** and rectangle **210D**.

[0036] Data from base graphic raster **202** and selection graphic raster **204** are directed to compositing engine **206**. Compositing engine

206 generates output graphic raster **208**, which is displayed on a display (not shown). As shown in Figure 2, compositing engine **206** creates output graphic raster **208** such that the pixel values for selected objects **211A**, **211B**, **211C**, **211D** are modified in output graphic raster **208**. When output graphic raster **208** is displayed, selected objects **211A**, **211B**, **211C**, **211D** are highlighted. Compositing engine **206** creates output graphic raster **208** such that the pixel values for non-selected objects **211E**, **211F**, **211G** are the same as those of objects **209E**, **209F**, **209G** from base graphic raster **202**.

[0037] Figure 3 is a flow chart diagram illustrating an example routine **300** for highlighting selected object(s) on a display in accordance with a particular embodiment of the invention. Base graphic data is obtained in block **302**. The base graphic data obtained in block **302** comprises at least one, and typically a plurality of, graphic object(s). At block **304**, the base graphic data is rasterized according to the requirements for the display on which the graphic data will be displayed. Rasterizing may be done using any suitable rendering engine which may comprise hardware, software or some combination thereof. The output of the rasterizing process of block **304** is a base graphic raster, which is a rasterized version of the base graphic data obtained in block **302**.

[0038] Block **306** involves a query as to whether any graphic object(s) within the base graphic data have been selected by a user for highlighting. If there are no object(s) to be highlighted, then the base graphic raster generated in block **304** is displayed on the computer display at block **308**. If it is determined in block **306** that one or more

object(s) within the base graphic data are to be highlighted, then selection graphic data is obtained in block **310**. The selection graphic data obtained in block **310** may be generated using any of a number of different techniques which are explained in further detail below. In one possible embodiment, obtaining selection graphic data in block **310** comprises copying selected object(s) from the base graphic data into the selection graphic data. The selection graphic data obtained in block **310** is rasterized in block **312** to generate a selection graphic raster. The selection graphic data may be rasterized in using the same rendering engine used to rasterize the base graphic data in block **304**.

[0039] In block **314**, the base graphic raster (generated in block **304**) is composited with the selection graphic raster (generated in block **312**) to produce an output graphic raster. As part of the compositing process of block **314**, the pixels of the output graphic raster which are associated with selected object(s) are modified such that the selected object(s) appear highlighted when displayed. In one possible embodiment, the compositing process of block **314** comprises copying the pixel values from the base graphic raster, using the selection graphic raster to determine which pixels of the base graphic raster correspond to selected object(s), and then modifying the pixel values of the output graphic raster for these pixels, such that the selected object(s) will appear highlighted when displayed. In other possible embodiments, the compositing process of block **314** comprises a pixel by pixel (or bit by bit) function of the base graphic raster and the selection graphic raster to determine whether the corresponding pixel (or bit) of the output graphic

raster corresponds to a selected object and should therefore be modified to display highlighting.

[0040] In block **316**, the output graphic raster is displayed on a display. Displaying the output graphic raster on the display may comprise copying the output graphic raster into a buffer of a display adapter, for example. Where one or more object(s) have been selected by a user, these object(s) will appear highlighted when the output graphic raster is displayed in block **316**. The highlighting occurs because pixel values associated with the selected object(s) within the output graphic raster are modified during the compositing process of block **314**. As discussed above, different visual cues may be used for highlighting. In some alternative embodiments of the invention, the base graphic raster (generated in block **304**) is displayed first and then the base graphic raster and the selection graphic raster are subsequently composited directly into a display buffer such that selected object(s) are highlighted.

[0041] The highlighting techniques described above and depicted in Figures 1-3 involve applying highlighting during the compositing process (i.e. after rendering the base graphic data to obtain a base graphic raster and after rendering the selection graphic data to obtain a selection graphic raster). As such, these highlighting techniques are capable of providing resolution independent highlighting. For example, when a user zooms in on particular features of a displayed image, the base graphic data and selection graphic data are re-rendered at a higher resolution. The re-rendered base graphic raster and selection graphic raster are then composited to produce a new output graphic raster at the

higher resolution. Any highlighting applied to the output graphic raster during compositing will also have the higher resolution. This is particularly significant when the highlighting has the form of a pattern applied to parts of the image corresponding to selected objects.

[0042] The highlighting techniques of Figures 1- 3 are also well suited for circumstances where a user is frequently zooming and/or panning a displayed image. When a user pans a displayed image or zooms in or out on a displayed image without changing the object(s) that are selected, the process of obtaining selection graphic data (i.e. block **310** in Figure 3) need only be performed once.

[0043] A more detailed implementation of the invention will now be described with reference to Figure 4. As shown in Figure 4, a computer graphic application **400** is running in a computer **402** which includes a data processor **403**. Computer **402** has a display **404** and one or more user input devices **406**. Graphic application **400** has access to a rendering engine **410**. Rendering engine **410** may comprise hardware, software or a combination of hardware and software which receives data representing graphic objects to be shown on display **404** and produces a corresponding graphic raster suitable for displaying on display **404**.

[0044] Application **400** permits a user to interact with base graphic data **412**. Base graphic data **412** could, for example, include graphics stored in a suitable form for printing a print job. Base graphic data **412** may include various categories or formats of graphic objects, such as text **414A**, bitmap images **414B**, and vector graphics **414C**, for example.

Base graphic data **412** may contain, any practical number of different graphic objects.

[0045] When a user causes application **400** to open or otherwise display base graphic data **412**, application **400** passes base graphic data **412** to rendering engine **410**. Rendering engine **410** produces a base graphic raster **411** which includes a rasterized representation of the objects in base graphic raster **412**. Processor **403** may cause base graphic raster **411** to be displayed on display **404** by sending base graphic raster **411** to display buffer **424**. In the apparatus of Figure 4, any rasterized data received in display buffer **424** is displayed on display **404**. In the illustrated example, display **404** shows an image comprising circles **416A**, **416B**, **416C**, **416D**. A cursor **418** controlled by a pointing device **406A** may also be displayed on display **404**.

[0046] A user may select one or more objects by way of a user interface provided by computer **402**. For example, the user may direct pointing device **406A** to place cursor **418** over the display of an object to be selected and click a button to select the object. Application **400** may determine which object the user wishes to select from the coordinates of cursor **418** at the time the button is clicked. In the illustration of Figure 4, the user has selected circle **416C**, which appears highlighted on display **404**.

[0047] Upon selection of one or more objects, application **400** generates selection graphic data **419** for use in creating a selection

graphic raster **413**. In various embodiments of the invention, selection graphic data **419** is generated in different ways. In some embodiments of the invention, selection graphic data **419** is generated by copying selected object(s) from base graphic data **412**. Selection graphic data **419** may include various categories or formats of graphic objects, such as text **414A**, bitmap images **414B**, and vector graphics **414C**, for example. Preferably, selection graphic data **419** has the same format as base graphic data **412**. For example, selection graphic data **419** and base graphic data **412** may both comprise a similar data structure, such as a file or a stream of data. As a more specific example, selection data **419** and graphic data **412** could both be in ADOBE™ PDF format. In some embodiments, selection graphic data **419** is obtained by creating a blank file having an appropriate format and copying selected objects from base graphic data **412** into the blank file.

[0048] Selection graphic data **419** is rasterized by rendering engine **410** to yield a selection graphic raster **413**. Compositing engine **420** receives base graphic raster **411** and selection graphic raster **413** and performs a function on this data to generate output graphic raster **422**. Output graphic raster **422** is then sent to display buffer **424** for displaying on display **404**. When output raster **422** is displayed on display **404**, pixels of output graphic raster **422** provide one or more visual cues (i.e. highlighting) which identifies selected object(s).

[0049] The highlighting technique described above in relation to Figure 4 involves applying highlighting during compositing (i.e. after rendering base graphic data **412** to obtain base graphic raster **411** and

after rendering selection graphic data **419** to obtain selection graphic raster **413**). As such, the highlighting technique of Figure 4 may provide resolution independent highlighting, as described above with reference to Figures 1-3.

[0050] The highlighting technique described above in relation to Figure 4 is also well suited for circumstances where a user is frequently zooming and/or panning a displayed image. Obtaining selection graphic data **419** does not need to be repeated when a user pans a displayed image or zooms in or out on a displayed image as long as the same object(s) remain selected.

[0051] Compositing engine **420** uses base graphic raster **411** and selection graphic raster **413** to create output graphic raster **422**. Output graphic raster **422** comprises pixel values similar to those of base graphic raster **411**, except for in pixels corresponding to selected object(s), where compositing engine **420** modifies the pixel values such that selected object(s) appear highlighted when displayed. Compositing engine **420** uses the pixels of selection graphic raster **413** to determine which pixels correspond to selected object(s). The pixels of selection graphic raster **413** corresponding to selected object(s) are assigned pixel values which may be referred to as "highlighting values". Pixels of selection graphic raster **413** having highlighting values cause compositing engine **420** to apply highlighting to corresponding pixels in output graphic raster **422** (i.e. compositing engine **420** alters the values of those pixels in output graphic raster **422** which correspond with pixels in selection graphic raster **413** that have highlighting values to be different from the values of

the corresponding pixels in base graphic raster **411**). The highlighting values of the pixels in selection graphic raster **413** may comprise color values of the pixels. Other pixels of selection graphic raster **413** do not correspond to selected object(s). These pixels of selection graphic raster **413** are assigned pixel values which may be referred to as "non-highlighting values". Pixels of selection graphic raster **413** having non-highlighting values cause compositing engine **420** to set the values of corresponding pixels in output graphic raster **422** to be the same as the values of the corresponding pixels in base graphic raster **411** (i.e. compositing engine does not modify the values of these pixels in output graphic raster **422**).

[0052] In general, the function performed by compositing engine **420** to generate output graphic raster **422** may be a function of one or both of the pixel values of selection graphic raster **413** and the pixel values of base graphic raster **411**. For example, where all of the pixels of selection graphic raster **413** have non-highlighting values (i.e. the user has not selected any objects that are in the field of view of display **404**), output graphic raster **422** may be populated by copying corresponding pixel values from base graphic raster **411**. Where any pixels of selection graphic raster **413** have highlighting values, compositing engine **420** performs a highlighting function to generate pixel values for the corresponding pixels of output graphic raster **422**. One possible highlighting function involves copying pixel values from base graphic raster **411** into output graphic raster **422** and replacing the corresponding pixel values of output graphic raster **422** with values from any corresponding pixels of selection graphic raster **413** which contain

highlighting values. The replacement may be performed during or after the copying. In other embodiments, compositing engine **420** performs a pixel by pixel (or bit by bit) function of base graphic raster **411** and selection graphic raster **413** to determine whether the corresponding pixel (or bit) of output graphic raster **422** corresponds to a selected object and should therefore be modified to display highlighting.

[0053] In an additional or alternative highlighting function, the highlighting values of pixels in selection graphic raster **413** determine a particular highlighting technique for compositing engine **420** to use. For example, for pixels in selection graphic raster **413** which have a first highlighting value (or a highlighting value within a first range), compositing engine **420** may apply a certain visual cue (i.e. highlighting technique) to corresponding pixels of output graphic raster **422** and for pixels in selection graphic raster **413** which have a second highlighting value (or a highlighting value within a second range), compositing engine may apply a different visual cue to corresponding pixels of output graphic raster **422**, and so on. In a variation of this technique, a highlighting value may comprise, or may be used to identify, a pointer to a particular location in a look up table. The entries of the look up table may be controlled by the user, by processor **403** or by application **400** to specify different highlighting techniques, patterns, colors or the like for compositing engine **420** to apply to corresponding pixels of output graphic raster **422**. Such look up tables may be referred to as "index color tables". In yet another example, compositing engine **420** performs a highlighting routine using the combination of the pixel values of base graphic raster **411** and the highlighting values of the pixels of selection

graphic raster **413** to determine a particular way in which to apply highlighting to corresponding pixels of output graphic raster **422**.

[0054] In general, compositing engine **420** highlights selected object(s) by generating output graphic raster **422** to have different pixel values than those of base graphic raster **411** in pixels of output graphic raster **422** corresponding to selected object(s). These different pixel values in output graphic raster **422** provide one or more visual cues that identify the selected object(s). Such visual cue(s) may include a wide variety of highlighting techniques. For example, compositing engine **420** may cause selected object(s) to be highlighted by one or more of:

- Altering the color and/or intensity of all of pixels within the fill area of the selected object(s).
- Altering the color and/or intensity of a pattern of pixels within the fill area of the selected object(s). For example, the color of every *N*th pixel in every *M*th row within such area(s) may have its color value altered. Other patterns may also be provided. In some embodiments of the invention the scale of a highlighting pattern is fixed relative to the display on which the output graphic raster is displayed. In such embodiments, the pattern itself does not change significantly if the user causes the application to zoom in to provide a magnified view of a ll or part of a selected object.
- altering the color and/or intensity values of pixels on a boundary (i.e. stroke area) of a selected object.
- altering the color and/or intensity values of some of the pixels (e.g. in a pattern) on the boundary of a selected object.

Altering colors may involve inverting colors, intensifying colors, replacing colors or applying some other function to the colors.

[0055] Figure 5 is a block diagram schematically illustrating an example of compositing base graphic raster **411** and selection graphic raster **413** wherein different highlighting techniques are used for different types of graphic objects. In Figure 5, base graphic raster **411** is schematically illustrated as comprising a number of graphic objects, which include: text **509A**; parallelogram **509B**; circle **509C**; rectangle **509D**; triangle **509E**; star **509F**; and ellipse **509G**. Parallelogram **509B** and rectangle **509D** comprise both stroke (i.e. boundary) and fill objects, whereas circle **509C**, rectangle **509D**, triangle **509E**, star **509F** and ellipse **509G** comprise just stroke objects.

[0056] In Figure 5, a user has selected text **509A**, the stroke of circle **509C**, the stroke of rectangle **509D** and the fill of parallelogram **509B** for highlighting. Accordingly, in selection graphic raster **413**, the pixels associated with text **510A**, the stroke of circle **510C**, the stroke of rectangle **510D** and the fill of parallelogram **510B** are assigned highlighting values. Base graphic raster **411** and selection graphic raster **413** are provided as inputs to compositing engine **420** which generates output graphic raster **422**.

[0057] In output graphic raster **422**, the pixels associated with the selected objects are highlighted. Text **511A** is highlighted in output graphic raster **422** by bolding the text; the fill of parallelogram **511B** is highlighted by applying a pattern of color change to the fill of

parallelogram **511B**; and the stroke of circle **511C** and rectangle **511D** are highlighted by applying a pattern of color change to the stroke of circle **511C** and rectangle **511D**. Triangle **511E**, star **511F** and ellipse **511G** are not selected by the user and therefore do not appear highlighted in output graphic raster **422**. Although not shown in Figure 5, other visual cue(s) (i.e. highlighting technique(s)) could also be used by compositing engine **420** as discussed above.

[0058] In some embodiments of the invention, compositing engine **420** uses the highlighting values of the pixels in selection graphic raster **413** to specify a particular highlighting technique (i.e. visual cue) to apply to corresponding pixels of output graphic raster **422**. For example, when generating output graphic raster **422**, compositing engine **420** may alter the pixel values of output graphic raster **422** from the pixel values of corresponding pixels in base graphic raster **411** in different manners as a function of the highlighting value for the corresponding pixel in selection graphic raster **413**.

[0059] Base graphic data **412** may contain graphic objects which application **400** treats as being of different types. For example, a trapping application might treat traps and objects which specify other shapes differently. The highlighting value assigned to the pixels of selection graphic raster **413** may depend on the type of graphic object(s) that the user has selected. Thus, different types of graphic objects may be highlighted using different kinds of visual cue.

[0060] There is not always a 1:1 correspondence between color attributes specified for objects in base graphic data and pixel colors produced by a rendering engine. A rendering engine may perform functions such as anti-aliasing which result in slight variations in the output colors produced by the rendering engine. To prevent such color shifts from affecting the operation of compositing engine **420** compositing engine **420** may respond in the same manner to any highlighting value within a range of highlighting values.

[0061] Table I shows an example of how, when selected, different types of graphic objects may be assigned different highlighting values in selection graphic raster **413**. These different highlighting values may then be used by compositing engine **420** to produce output graphic raster **422** in which a different highlighting technique is used for any selected object(s) of each different type. Results similar to those of the technique described above and in Table I (i.e. where different highlighting techniques are used for different types of objects) may be obtained using index color tables.

TABLE I. Example of Using Different Highlighting Values for Different Types of Objects to Provide Different Highlighting Techniques

Type of Graphic Object	Highlighting Value in Selection Graphic Raster	Action Taken by Compositing Engine
Object Outline	0-42	Replace all pixels in object with color #1
Object Fill	43-84	Replace every *N*th pixel with color #2
Trap Outline	85-126	Replace all pixels in object with color #3
Trap Fill	127-169	Replace all pixels in object with color #3
Group Graphic Object Outline	170-212	Replace all pixels in object with color #4
Group Graphic Object Fill	213-255	Replace every *M*th pixel with alternative high/low intensity tints of color #4

[0062] Selection graphic data **419** may be generated using a number of techniques. In an embodiment discussed above, selection graphic data **419** is generated by copying selected object(s) from base graphic data **412** into selection graphic data **419**. Preferably, in addition to copying selected object(s) from base graphic data **412**, the generation of selection graphic data **419** involves assigning "highlighting attributes" to the selected object(s) in selection graphic data **419** .

[0063] As used in this description and the accompanying claims, a "highlighting attribute" is an attribute or characteristic of a graphic object which, when rendered, causes one or more pixels associated with the object to have highlighting values. For example, a highlighting attribute may be assigned to a selected object in selection graphic data **419**. When selection graphic data **419** is rasterized by rendering engine **410**, one or more pixels of the resulting selection graphic raster **413** that are associated with the selected object will be assigned highlighting values. The highlighting attributes may comprise color attributes and the highlighting values may comprise color values.

[0064] The generation of selection graphic data **419** may also comprise assigning "blank attributes" to certain object(s). As used in this description and the accompanying claims, a "blank attribute" is an attribute or characteristic of a graphic object which, when rendered, causes the pixels associated with the object to have non-highlighting values. Typically, objects assigned blank attributes will be non-selected objects. For example, a blank attribute may be assigned to a non-selected object in selection graphic data **419**. When selection graphic data **419** is rasterized by rendering engine **410**, the pixels of the resulting selection graphic raster **413** that are associated with the non-selected object will be assigned non-highlighting values.

[0065] In preferred embodiments of the invention, selection graphic data **419** is generated using simplified version(s) of selected object(s). For example, where a selected object comprises a bitmap image, the

details of the bitmap image may not be necessary to the highlighting process. The bitmap image may be represented in selection graphic data **419** by a shape which has a substantially similar boundary to that of the bitmap image. The simplified shape may be assigned a highlighting attribute. Rendering such a representative shape to prepare selection graphic raster **413** may be performed more quickly than rendering the bitmap image, especially where the bitmap image has a different resolution than is required for display **404**. A bitmap image which has a resolution different from that desired for display **404** could also be simplified by re-rendering it to have the desired resolution. Complicated vector objects may also be simplified by replacing them in selection graphic data **419** with shapes having boundaries substantially similar to those of selected vector objects.

[0066] In some cases, base graphic data **412** will contain some objects which overlap with and hide portions of other objects. For some applications, it may be desirable to highlight only the non-hidden (i.e. exposed or visible) portions of an object. In such cases, it is desirable to create a selection graphic raster **413** where only pixels corresponding to exposed portions of selected object(s) are assigned highlighting values. When only pixels corresponding to exposed portions of selected object(s) are assigned highlighting values in selection graphic raster **413**, the resulting output graphic raster **422** produced by compositing engine **420** will only highlight pixels corresponding to exposed portions of selected object(s). Creating a selection graphic raster **413** wherein only pixels corresponding to exposed portions of selected object(s) are assigned highlighting values may be accomplished by generating selection graphic

data **419**, such that only exposed portions of selected object(s) are assigned highlighting attributes.

[0067] In a particular embodiment of the invention, selection graphic data **419A** (see Figure 6) is generated by copying selected object(s) from base graphic data **412** into selection graphic data **419A** and copying at least the non-selected objects which overlap the selected object(s) from base graphic data **412** into selection graphic data **419A**. In selection graphic data **419A**, the selected object(s) are assigned highlighting attributes and the non-selected objects which overlap the selected object(s) are assigned blank attributes. In areas where the non-selected objects overlap the selected object(s), the highlighting attributes that were assigned to the selected object are replaced with blank attributes.

[0068] In the example of Figure 6, base graphic data **412** includes graphic objects **604A**, **604B**, and **604C**. In the illustrated example, graphic object **604B** is selected and objects **604A**, **604C** are non-selected objects. Non-selected graphic objects **604A** and **604C** overlap with selected graphic object **604B**. Selection graphic raster **419A** is created by copying graphic objects **604A**, **604B** and **604C** into selection graphic raster **419A** to provide corresponding copied graphic objects **606A**, **606B**, and **606C**. Non-selected overlapping objects **606A** and **606B** have their highlighting attributes set to blank and selected object **606B** is assigned a hightlighting attribute.

[0069] Selection graphic data **419A** is rasterized by rendering engine **410** to yield selection graphic raster **413** wherein only pixels corresponding to the exposed portion of object **606B** have highlighting values.

[0070] In some embodiments of the invention, application **400** checks selected objects to determine whether a selection graphic raster can be created without the necessity of including some or all of the non-selected objects in the selection graphic data. If so then application **400** may assemble the selection graphic data in a manner that avoids including objects corresponding to some or all of the non-selected objects in the selection graphic data.

[0071] In an alternative embodiment, also illustrated in Figure 6, the creation of selection graphic raster **413** involves rasterising a selection graphic data **419B** which contains one or more newly defined graphic objects **608**. The newly defined graphic objects have the shape of exposed portion(s) of a selected object that is overlapped by one or more non-selected objects.

[0072] Using this technique, the pixels in selection graphic raster corresponding to any portion of a selected object that is overlapped by non-selected objects will be rendered by rendering engine **410** to have non-highlighting values. The pixels in selection graphic raster **413** will have highlighting values only in regions corresponding to object **608** which correspond, in turn, to exposed portions of selected object(s).

[0073] In some cases, other techniques may be used to generate a selection graphic raster in which pixels corresponding to exposed objects, exposed portions of objects and/or boundaries of exposed portions of objects have highlighting values. In some such techniques, selection graphic data **419** can be generated in whole or in part using only exposed objects or exposed portions of objects. For example:

- Application **400** may comprise, or otherwise work with, an application, such as some trapping applications, which identifies the boundaries of exposed objects (and boundaries of exposed portions of objects) as part of its operation. These boundaries may be identified in base graphic data **412**, in base graphic raster **411** and/or in an internal display list which is directly or indirectly accessible to the application. Information specifying these boundaries may be used to generate new objects which represent the exposed portions of selected objects. Thus, only these new objects, representative of exposed portions of selected objects, need be introduced into selection graphic data **419**. In a particular embodiment of this technique, a path describing the outline of the exposed portion of a selected object may be created from the internal display list of the trapping application and used to generate selection graphic data **419**. A trapping application may recognize boundaries between objects as distinct objects.
- Objects (and/or boundaries of objects) which are selected and which are known to be exposed may be copied from base graphic data **412** directly into selection graphic data **419**. This is appropriate for objects in the foreground which are not or cannot be overlapped by other objects. An example of a type of object

which would not normally be overlapped by any other object is a trap.

As with other techniques of generating selection graphic data **419**, these techniques where only exposed portions of selected objects and/or objects which are known to be exposed are used to generate selection graphic data **419** may comprise assigning highlighting attributes to the objects in selection graphic data **419**.

[0074] In some embodiments of the invention, highlighting may comprise animating some or all selected objects. Animation may be performed by causing compositing engine **420** to create a plurality of output graphic rasters **422** in which selected objects are highlighted using different patterns and then displaying the plurality of output graphic rasters in rotation.

[0075] Certain implementations of the invention comprise computer processors which execute software instructions which cause the processors to perform a method of the invention. For example, one or more processors in a computer may implement the methods of Figure 3 by executing software instructions in a program memory accessible to the processors. The invention may also be provided in the form of a program product. The program product may comprise any medium which carries a set of computer-readable signals comprising instructions which, when executed by a computer processor, cause the data processor to execute a method of the invention. Program products according to the invention may be in any of a wide variety of forms. The program product may comprise, for example, physical media such as magnetic data

storage media including floppy diskettes, hard disk drives, optical data storage media including CD ROMs, DVDs, electronic data storage media including ROMs, flash RAM, or the like or transmission-type media such as digital or analog communication links. The computer-readable signals may be compressed or encrypted such that, upon decompression and/or decryption, instructions are made available to a computer processor which can cause the processor to execute a method of the invention.

[0076] Where a component (e.g. a software module, processor, assembly, device, circuit, etc.) is referred to above, unless otherwise indicated, reference to that component (including a reference to a "means") should be interpreted as including as equivalents of that component any component which performs the function of the described component (i.e., that is functionally equivalent), including components which are not structurally equivalent to the disclosed structure which performs the function in the illustrated exemplary embodiments of the invention.

[0077] As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. For example:

- In the above description, the rendering engine obtains base graphic data separately from selection graphic data. In alternative embodiments of the invention, selection graphic data **104** may be included in the base graphic data **102** and the rendering engine may be adapted to generate two sets of raster.

- The selection graphic raster and base graphic raster do not need to have the same resolutions. If it is acceptable for the boundaries of highlighting to be off by a small margin of error, then the selection graphic raster could have a lower resolution than the base graphic raster and the compositing engine could be configured to treat each pixel of the selection graphic raster as specifying a highlighting value for a corresponding block of pixels in the base graphic raster (e.g. where the selection graphic raster has half of the resolution of the base graphic raster, each pixel of the selection graphic raster may correspond to a 2×2 block of pixels in the base graphic raster) in the base graphic raster. This permits the selection graphic raster to be made smaller and reduces the time taken to create the selection graphic raster.
- The highlighting technique depicted in Figure 4 and described above depicts a display buffer **424**. It is common for a computer system **402** to comprise a display buffer **424**, the contents of which are displayed directly on the display **404**. Figure 4 depicts other data storage/data handling devices, which may not be required for the invention. In some embodiments, compositing engine **420** may output directly into display buffer **424**, such that no independent data storage/data handling hardware is required for output graphic raster **422**. In another possible embodiment, compositing engine **420** may output directly overtop of base graphic raster **411** (or selection graphic raster **413**) and then the contents of this buffer may be copied to display buffer **424** for display. While these embodiments do not allow independent simultaneous access to output graphic raster **422** and base graphic raster **411** (or selection

graphic raster **413**), they help to reduce the required data storage/data handling hardware. Those skilled in the art will appreciate that the highlighting techniques disclosed herein may encompass other well known approaches for reducing the amount of data storage/data handling hardware.

- The above description relates mostly to displaying graphics on a computer display. Similar techniques may be used for printing graphics.
- Graphics technology involves many other sophisticated techniques which, although applicable in conjunction with this invention, are not described in detail herein. For example, it is a standard practice to render graphic data such that the resulting rasterized data is slightly larger than the display. This allows a user to pan the displayed image by a small amount without re-rendering. It should be understood that this and other similar well known graphics techniques may be applied in conjunction with this invention.
- Instead of displaying the base graphic data directly when no objects are being highlighted, a system according to the invention could create a selection graphic raster having only non-highlighting values, create an output graphic raster by compositing a base graphic raster and the selection graphic raster and display the output graphic raster.
- Instead of having a compositing engine which patterns areas to be highlighted, a system according to the invention could provide a special rendering engine which patterns areas to be highlighted in the selection graphic raster.

Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.